**SEMESTER - II**

**Paper - I : Quantum Mechanics**

**Max. Marks : 55**
**Time : 3 Hrs**

Note : Nine questions will be set and students will attempt 5 questions. Question No. 1 will be compulsory consisting of 4 parts based on the conceptual aspects of the whole syllabus. The answers should not be in yes/no. In addition to Question No. 1 there will be four Units in the question-paper each containing two questions belonging to four Units in the syllabus. Students will select one question from each unit.

## UNIT - I

Separation of three dimensional Schrödinger equation for spherically symmetric potential into angular and radial equations, application to hydrogen atom problem, solution of radial equation and energy eigenvalues.
Matrix Mechanics : Matrix algebra preliminaries, transformation and diagonalisation of matrices, infinite matrices, unitary transformations, representation of operators and wave functions as matrices, Hilbert space, Dirac's ket and bra notation.
Time development of quantum systems, Schrodinger, Heisenberg and interaction pictures, relation with classical equation of motion, Solution of harmonic oscillator problem using matrix mechanics.

## UNIT - II

Theory of Angular momentum : Representation in Cartesian and polar coordinates, commutation relations, Infinitesimal rotation operator as angular momentum operator, Eigenfunctions and eigenvalues of $L^2$ and $L_z$ and connection with spherical harmonics, general angular momentum, eigenfunctions and eigenvalues of $J^2$ and $J_z$, matrix representation of angular momentum operators.
Spin angular momentum and Pauli spin matrices. Addition of two angular momenta, Clebsch Gordan (C.G.) coefficient and its properties, value of C.G. coefficient for $J_1 = 1/2$ and $J_2 = 1$.

## UNIT - III

Theory of scattering : Scattering amplitude and cross section, Scattering by spherically symmetric potential, method of partial waves, optical theorem, phase shift in terms of potential, low energy scattering, sign of phase shift, scattering length. Green's function in scattering theory and expression for scattering amplitude, Born series, first Born approximation, scattering of an electron by a screened coulomb potential in first Born approximation, Validity of first Born approximation.

## UNIT - IV

Time independent perturbation theory : First order and second order non-degenerate and degenerate perturbation theory. Applications : Zeeman effect without spin, He atom (ground state), Linear Stark effect in hydrogen atom.

Time dependent perturbation theory : constant and harmonic perturbations, Golden rule for transition probability, Interaction of single electron atom with electromagnetic field (semiclassical treatment only), induced absorption and emission.

Identical particles and spin : Indistinguishability of identical particles, symmetry of wave functions, spin and statistics, Pauli exclusion principle. Applications. Construction of spin functions for two electron systems and consequences of symmetry effects (spin and space) in the study of He atom problem (Ortho- and para-helium).

**References**


1. Quantum Mechanics - L.I. Schiff
2. Quantum Mechanics - J.L. Powell and B. Crasemann
3. Quantum Mechanics - Merzabacher
4. Quantum Mechanics - J.J. Sakurai
5. Quantum Mechanics - Ghatak and Loknathan
6. Quantum Mechanics - Mathews and Venkatesan
7. Quantum Mechanics - V.K. Thankappan
8. Quantum Mechanics - M.P. Khanna
9. Quantum Mechanics - B.H. Bransden and C.J. Joachain

## SEMESTER - II

**Paper - II : Electromagnetic Theory**

**Max. Marks : 55**
**Time : 3 Hrs**

Note : Nine questions will be set and students will attempt 5 questions. Question No. 1 will be compulsory consisting of 4 parts based on the conceptual aspects of the whole syllabus. The answers should not be in yes/no. In addition to Question No. 1 there will be four Units in the question-paper each containing two questions belonging to four Units in the syllabus. Students will select one question from each unit.

### UNIT - I

Electromagnetic waves in a homogeneous medium, Uniform plane waves, Wave equation for a conducting media, Sinusoidal time variations, Conductors and dielectrics, Direction cosine of a plane wave, Reflection and refraction of plane waves, Surface Impedence Poynting Theorem, Instantaneous, average and complex poynting vector, power loss in a plane conductor.

### UNIT - II

Interaction of fields and matter, Equation of motion for charged particles, Force and motion, Circular motion in a magnetic field, Crossed field motion of charged particle.
Frequency response of dielectric materials, TE and TM waves in rectangular and circular guides, attenuation factor and Q of a wave guide.

### UNIT - III

Radiation, Potential function and the electromagnetic field, The oscillating dipole power radiated by a current element, Short antennas Power radiated by a monopole or half wave dipole, Electromagnetic field close to an antenna.
Antenna fundamentals, Network Theorems, Directional properties of dipole antennas, Travelling wave antennas, Two element array. Horizontal patterns in broadcasting arrays.
Multiplication of patterns, Effect of earth on vertical patterns, Binomial arrays, Antenna gain and effective area.

## UNIT - IV

Ionosopheric propagation, Introduction to ionosphere, Effective C and O of ionized gas, Reflection and refraction of waves by the ionosphere, Variations in the ionosphere, Attenuation factor for ionospheric propagation, Sky wave transmission, Effect of earths magnetic field, Wave propagation in the ionosphere, Faraday rotation, Other ionospheric phenomenon.

### References


1. Electromagnetic Waves and Radiating Systems (2nd Ed.) - Jordan and Balmain, PHI.
2. Electromagnetics - Kraus, Mc Graw Hill
3. Classical Electromagnetic Theory - Reitz and Millford.
4. Classical Electromagnetic Theory - Phillps and Phnofaky.

# SEMESTER - II

**Paper - III : Applied Nuclear Science**

**Max. Marks : 55**
**Time : 3 Hrs**

Note : Nine questions will be set and students will attempt 5 questions. Question No. 1 will be compulsory consisting of 4 parts based on the conceptual aspects of the whole syllabus. The answers should not be in yes/no. In addition to Question No. 1 there will be four Units in the question-paper each containing two questions belonging to four Units in the syllabus. Students will select one question from each unit.

## UNIT - I

Qualitative description of various modes of energy loss of a charged particles in matter, Classical stopping power equation for electronic energy-loss (no derivation) with significance of various terms involved, Behaviour of electronic energy-loss curve as a function of ion velocity, Concept of energy and range straggling;

Interaction of gamma radiation with matter outlining the features of Photoelectric, Compton and Pair production processes, Linear and mass attenuation coefficients of gamma rays in matter, Positron annihilation in matter.

## UNIT - II

Basic principle and mechanism of GM Counter, The Geiger discharge, Development of pulse and quenching, dead time, Geiger plateau, counting efficiency.

Scintillation detectors: The absorption process, Scintillation process, Pulse formation, Mechanism of scintillations detectors, Energy resolution of scintillation detectors.

Silicon Surface barrier detector: Basic principle, construction, working and applications

Li drifted Ge and Si detectors: Basic consideration, Basic principle, construction, working and applications. Energy resolution, Fano factor, Sensitivity and efficiency

HPGe detector: Basic principle, construction and working.

## UNIT - III

Neutron sources: $\alpha$-beryllium source, Radium-beryllium source, plutonium-beryllium source, Americium-beryllium source, Photo neutron source, Reactors - as neutron source, Nuclear reactions - as neutron source.

Classification of neutrons on the basis of energy, Prompt and delayed neutrons, Neutron moderators and their properties, Dynamics of elastic scattering of neutrons, Angular distribution of neutrons, Average logarithmic decrement in energy of neutrons, Slowing down power of moderator, Moderating ratio, Diffusion of neutron and Fermi age equation.

## UNIT - IV

Fissile and Fertile materials, Characteristics and production of fissile materials, Classification of nuclear reactors, Neutron economy and multiplication factor, calculation of critical size of reactor, Concept of control of reactor, Properties of reactor shield, Fast breeder reactor, Concept of breeding, Doubling time, Reactor materials and basic principle, Basic concept of fusion reactor.

Desired characteristic of neutron detectors, $BF_3$ counter.

**References**


1. Elements of Nuclear Physics - LF Curtis.
2. Elements of Nuclear Physics - W.E. Burcham
3. Elements of Nuclear Physics by W.E. Meyerhof.
4. Nuclear Radiation Detectors - S.S. Kapoor and V.S. Ramamurthy.
5. Technique for Nuclear and Particle Physics experiment - W.R. Leo.
6. Experimental Nuclear Physics - R.M. Singru

## SEMESTER - II

**Paper - IV : Condensed Matter Physics and Nano Technology**

**Max. Marks : 55**
**Time : 3 Hrs**

Note : Nine questions will be set and students will attempt 5 questions. Question No. 1 will be compulsory consisting of 4 parts based on the conceptual aspects of the whole syllabus. The answers should not be in yes/no. In addition to Question No. 1 there will be four Units in the question-paper each containing two questions belonging to four Units in the syllabus. Students will select one question from each unit.

### UNIT - I

Lattice Dynamics : Lattice vibrations of 3D solids, Quantization of lattice vibrations, Diffraction of X-rays, electrons and neutrons by a vibrating lattice, Debye-Waller factor, Anharmonicity and thermal expansion, Electronic Energy Bands : Bloch's theorem, Tight-binding method, Orthogonalized plane wave method, Pseudopotential method, Conduction electrons in uniform external magnetic fields and Cyclotron resonance, de Haas-van Alphen effect.

### UNIT - II

Surfaces and Interface : Work function and contact potential, Thermoionic emission, Superlattices, Quantum wells, Quantum wires, Quantum dots and Carbon nanotubes. Correlation and Response : Dynamic correlation and linear response functions, Undamped and damped oscillators, Diffusion, Brownian motion and Langevin theory. Electron Gas in Metals : Hartree-Fock theory, exchange charge density and Fermi hole in a free-electron gas, Dielectric screening, Thomas-Fermi theory, Lindhard theory, Random phase approximation.

### UNIT - III

Quantum confined system : Nanostructure materials, quantum wells, quantum wires, quantum dots, coupled wells and superlattices. Transport in nanostructures : Tunneling in planar barrier structures - single and double barrier cases, quantized conductance in nanostructures, transport in quantum wave guide structures.

## UNIT - IV

Electronic devices : Velocity - modulation and quantum interference transistors, ballistic - injection devices, resonant - tunneling devices. Optical devices : Quantum - well lasers, surface-emitting lasers, quantum - wire lasers, blue quantum-well lasers, quantum - cascade lasers, multiple-quantum-well photodetectors.

**References**


1. Solid State Physics - N.W. Ashcroft and N.D. Mermin.
2. Principles of condensed matter physics - P.M. Chaikin and T.C. Lubensky
3. Principles of the theory of solids - J.M. Ziman
4. Quantum Heterostructures - Microelectronics and optoelectronic devices - V.V. Mitin, V.A. Kochelap and M.A. Stroscio
5. Transport in Nanostructures - D.K. Ferry and S.M. Goodnick.
6. Quantum Wells - Physics and Electronics of Two-dimensional Systems - A. Shik

# SEMESTER - II

**Paper - V : Electronics - II**

**Max. Marks : 55**
**Time : 3 Hrs**

Note : Nine questions will be set and students will attempt 5 questions. Question No. 1 will be compulsory consisting of 4 parts based on the conceptual aspects of the whole syllabus. The answers should not be in yes/no. In addition to Question No. 1 there will be four Units in the question-paper each containing two questions belonging to four Units in the syllabus. Students will select one question from each unit.

## UNIT - I

Number Systems : Introduction to Decimal, Binary, Octal, Hexadecimal Number Systems, BCD Codes, Interconversions of Decimal, Binary and BCD Numbers, Parity. Excess-3, Grey and Johnson Codes.
Logic Gates, Boolean Algebra and their Applications: Positive and Negative Logic. Different Logic Gates such as AND, OR, NOT, NAND, NOR, EX-OR, Boolean Axioms D'Morgan's Theorems : Statement, Verification and Applications.

## UNIT - II

K-Map for Simply of Boolean Functions upto Four Variables. One's Complement, 2's compliments, Half Adder, Full Adder, Half Subtractor, Full Subtractor .
Logic Families : DTL, TTL, ECL and CMOS, Parameters Like Power Dissipation, Speed, Fan In, Fan Out, Noise Immunity.

## UNIT - III

Combinational and Sequential Circuits : Multiplexer, Demultiplexer, Encoders, Decoders, Flip Flops (RS, JK, MS-JK, D,T), Shift Registers, Asynchrous and Synchrous Counters, Semiconductor Memories : ROM, RAM, EPROM.

## UNIT - IV

The Intel 8080/8085 Microprocessor : Introduction, the 8085 Pin Diagram and Functions, the 8085 Architecture, Addressing Modes, the

8080/8085 Instruction Set, the 8080/8085 Data Transfer Instructions, the 8080/8085 Arithmatic Instructions, The 8080/8085 Logical Instructions, The 8080-8085 Branch Instructions, The 8080-8085 Stack, I/O, and Machine Control Instructions.
Programming the 8080-8085 Microprocessor : Introduction, Straight-Line Programs, Looping Programs, Mathematical Programs.

**References**


1. Basic Electronics - B.L. Theraja
2. Microprocessor Architecture Programming and Applications - R.S. Gaonkar
3. Digital Computers - A.P. Malvino
4. Microprocessor and its applications - B.Ram
5. Integrated Electronics - Millman Halkias
6. Fundamentals of microprocessor and microcomputers - B.Ram